Using MODIS Ocean Color Data and Numerical Models to Understand the Distribution of Colored Dissolved Organic Matter in the Southern Ocean

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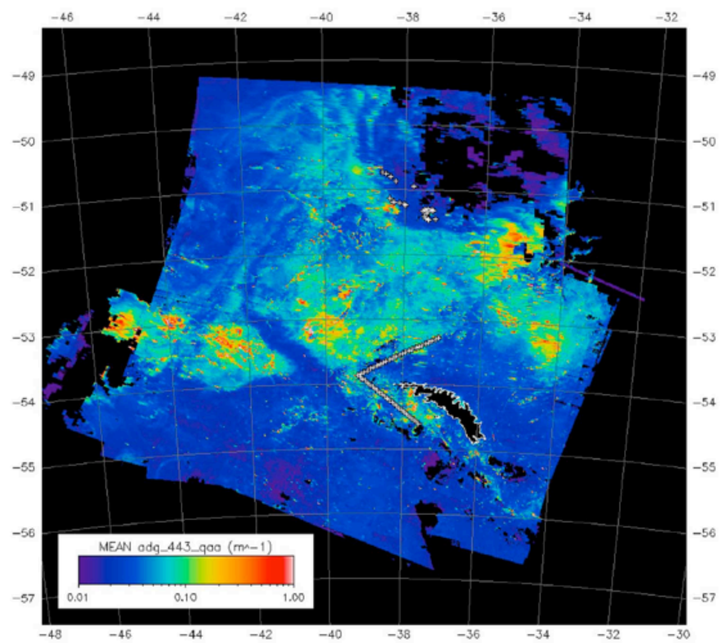


MODIS/VIIRS Science Team Meeting, Sheraton Silver Spring Hotel June 9, 2016

Goals:

1-To estimate the three- dimensional time evolving distribution of CDOM during the Southern Ocean Gas Exchange Experiment (SO_GasEx).

2-To diagnose the physical processes controlling CDOM distribution. Ultimately we want to model evolution of $a_g\Lambda$ (and other IOPs) to fill gaps in satellite coverage over periods of weeks.

Hypotheses:

1- That CDOM distribution in the Southern Ocean in time scales of ~weeks is controlled by physical processes. Biological processes are negligible.

2- That data assimilation of remote sensing and field data can produce IOP fields. Modeled products can compensate for lack of imagery in cloudy environments.

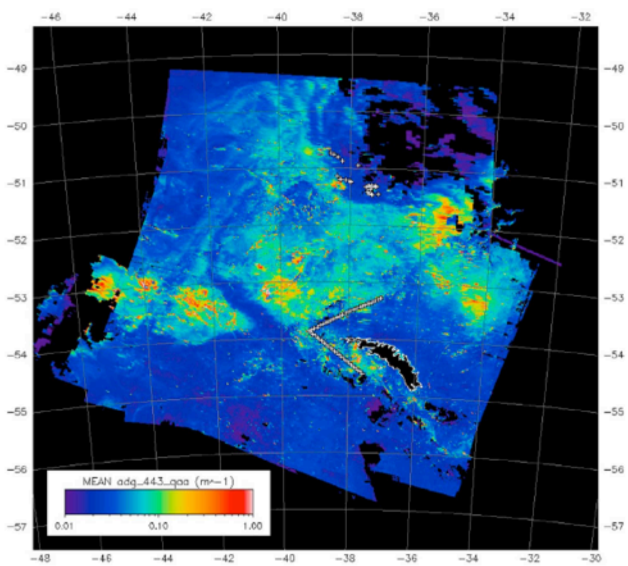
Background:

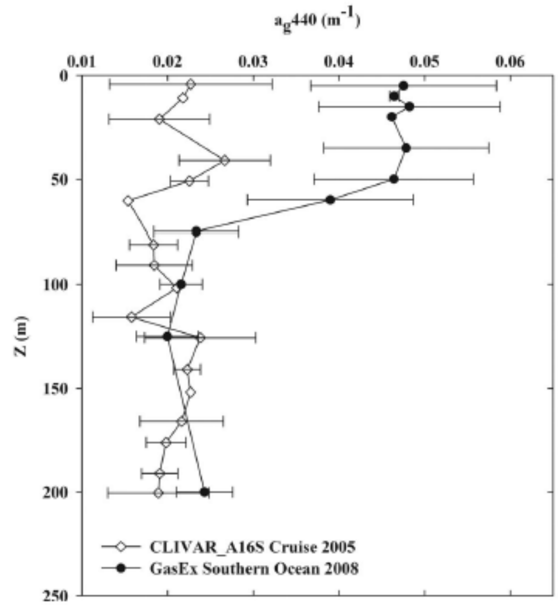
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, C00F07, doi:10.1029/2010JC006781, 2011

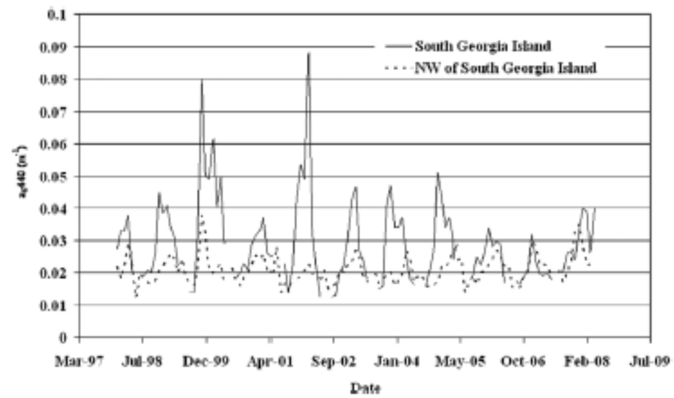
Horizontal and vertical distributions of colored dissolved organic matter during the Southern Ocean Gas Exchange Experiment

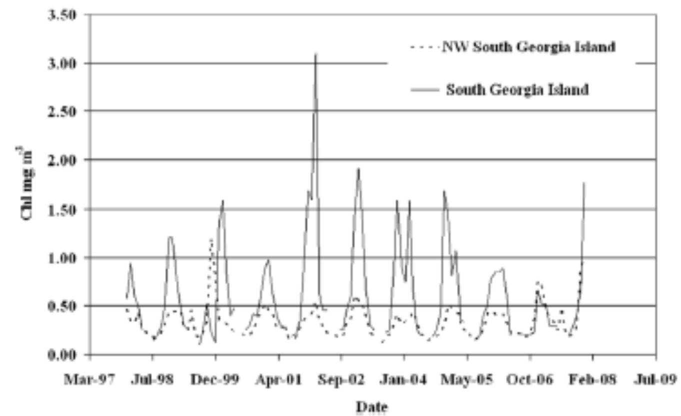
Carlos E. Del Castillo[1] and Richard L. Miller[2]

Received 31 October 2010; revised 11 April 2011; accepted 23 June 2011; published 22 September 2011.









$$\frac{dCDOM}{dt} = \varepsilon[\mu_b][CDOM] + a[CDOM]e^{-bz}$$

Seasonal changes in CDOM can be explained by bacterial production and photodegradation (Nelson et al., 2004).

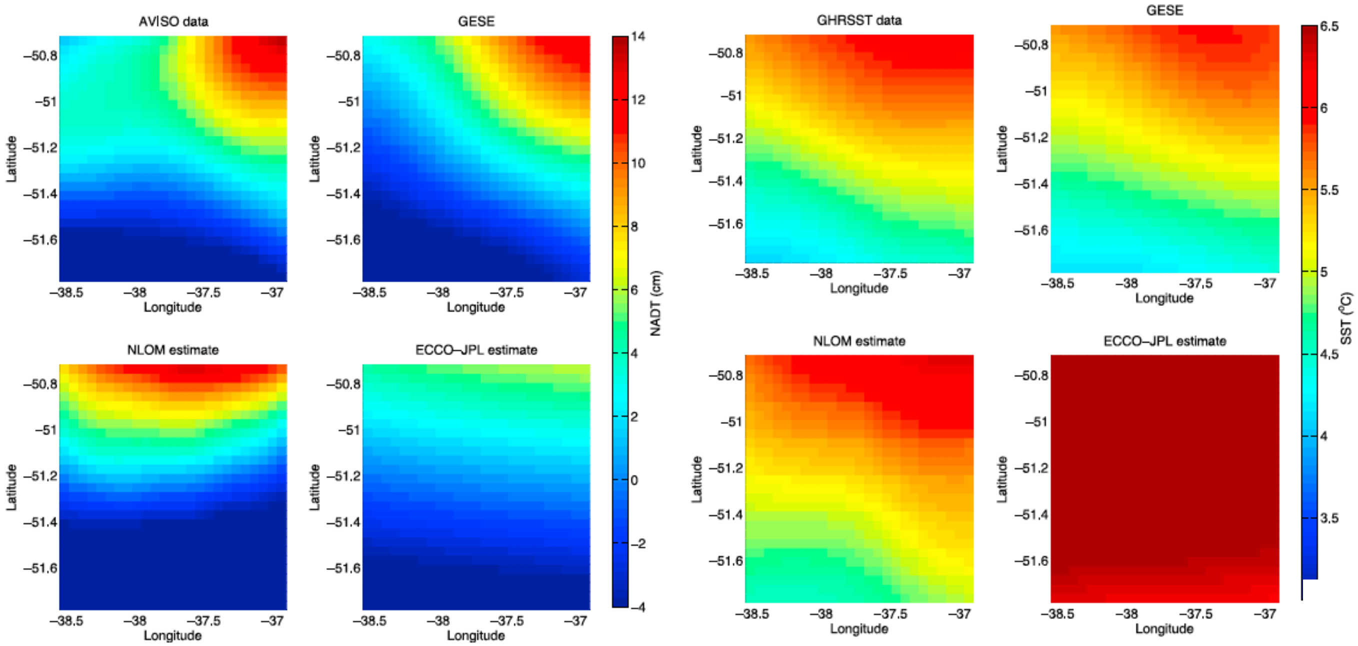
Background:

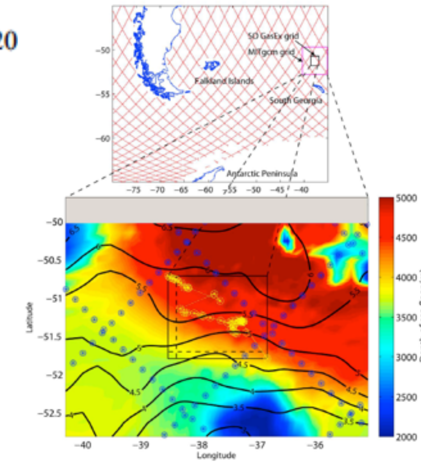
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, C00F07, doi:10.1029/2010JC006781, 20

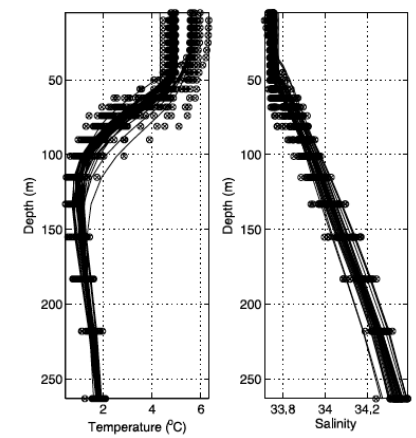
Upper ocean state estimation in the Southern Ocean Gas Exchange Experiment region using the four-dimensional variational technique

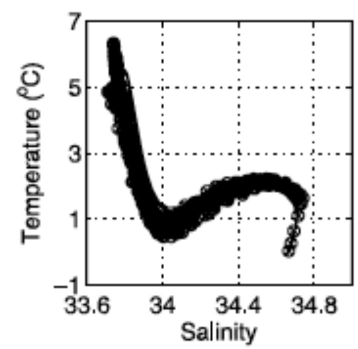
S. Dwivedi,[1] T. W. N. Haine,[2] and C. E. Del Castillo[3]

Received 2 July 2009; revised 22 November 2010; accepted 16 December 2010; published 5 March 2011.

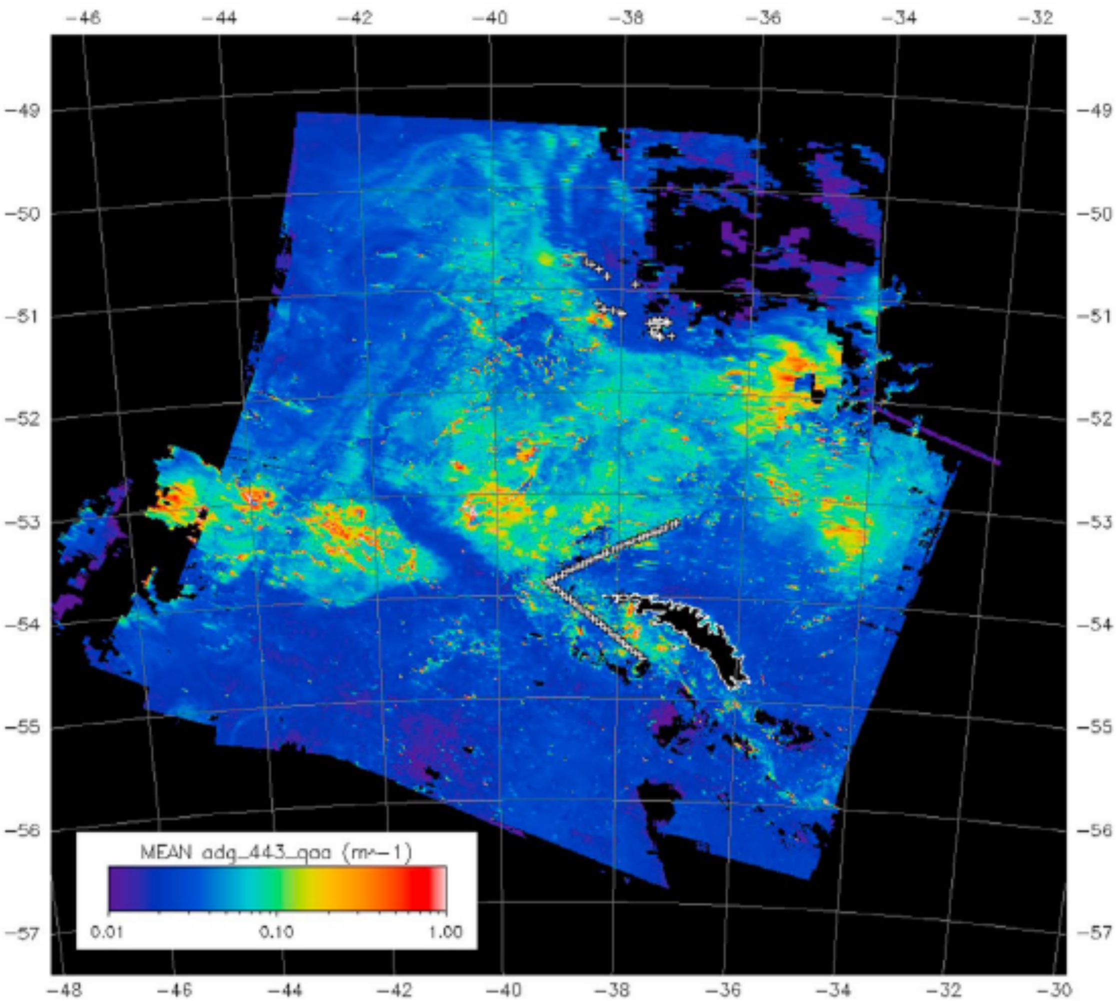








Our GESE estate estimation showed considerable skill in modeling upper ocean physical variables along the spatial and temporal domains of the SO GASEX



Issues:

1- We had poor match-ups. However, CDOM retrievals using QAA where in family with the field samples.

2- Don't have photodegradation parameters for the SO, assume that marine CDOM is similar everywhere.

Methods:

We developed a package for MITgcm to simulate advection and diffusion of CDOM at multiple wavelengths. We treated the CDOM absorption coefficients as passive tracers with time and space-varying sources and sinks. The absorption of light by CDOM and the associated photobleaching (photolysis) acted as the main sink. Following *Del Vecchio and Blough* [2002], the CDOM absorption coefficient a_{CDOM} after illumination for a short time Δt is

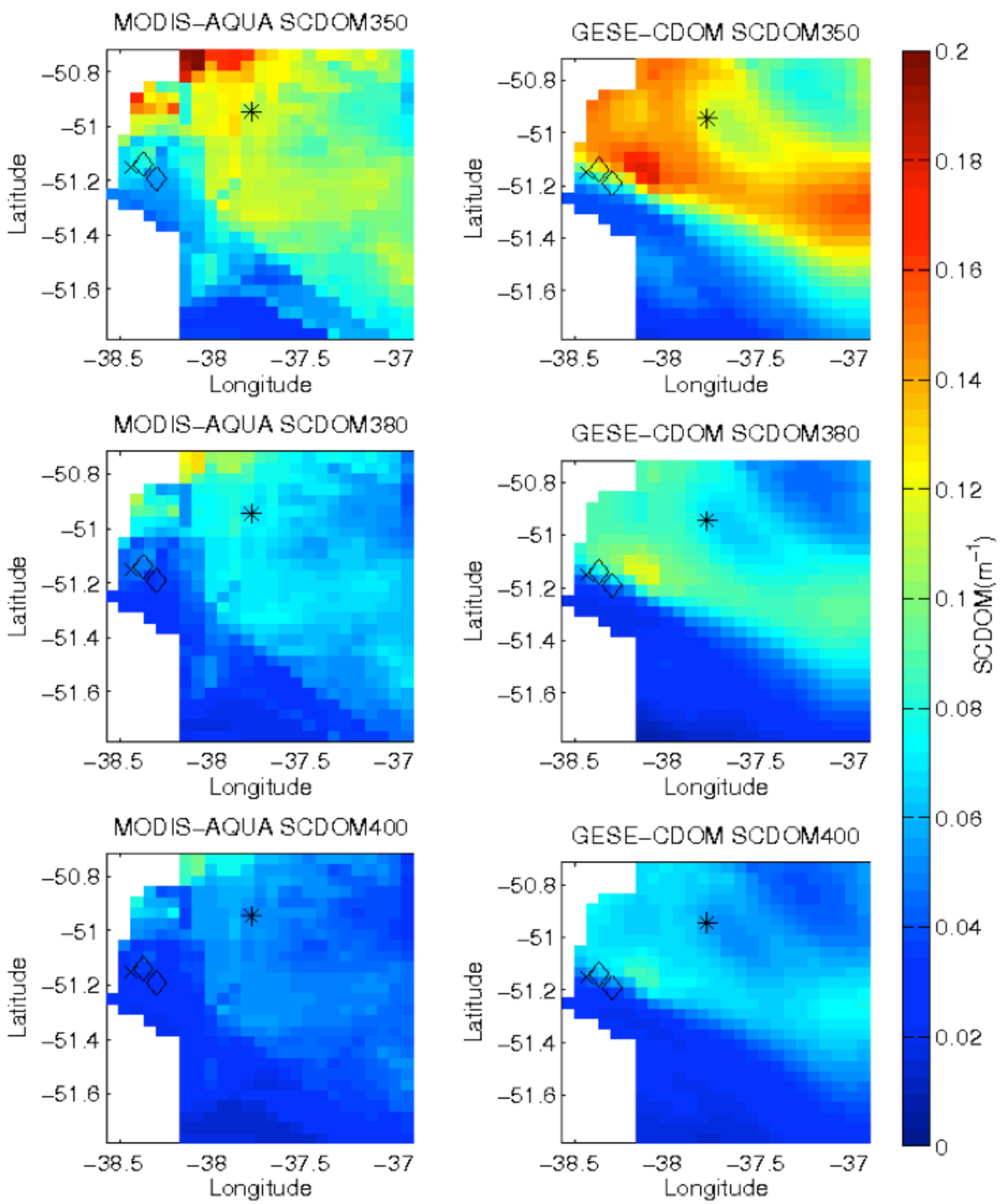
$$a_{CDOM}(\lambda, z) = a_{CDOM}(\lambda)\, e^{-f(\lambda, z)\,\Delta t},$$

where $f(\lambda, z)$ is the photobleaching rate at wavelength λ and depth z. It is given by

$$f(\lambda, z) = \sigma_P(\lambda)\, E(\lambda)\, e^{-k(\lambda, z)\, z}$$

where $\sigma_P(\lambda)$ is the photobleaching cross-section, $E(\lambda)$ is the solar irradiance at wavelength λ transmitted through the sea surface, and $k(\lambda, z)$ is the vertical attenuation coefficient which is approximated as $(4/3)\, a_{CDOM}(\lambda, z)$.

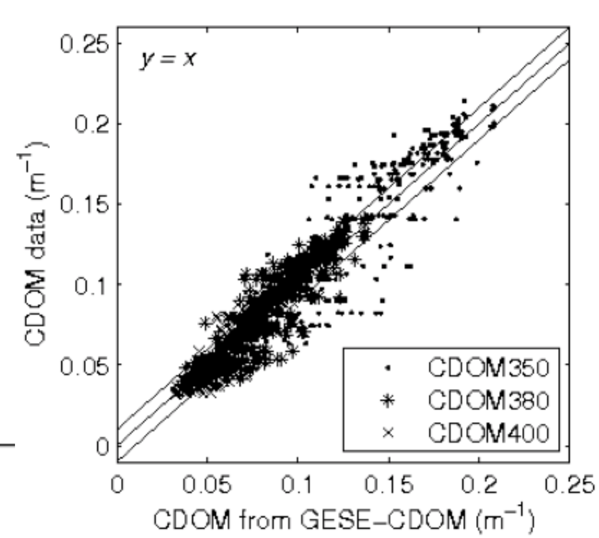
The CDOM model was run for three different wavelengths **350 nm**, **380 nm**, and **400 nm** using the hourly surface solar irradiance obtained from the OASIM radiative transfer model (*Gregg and Casey* [2009]) .

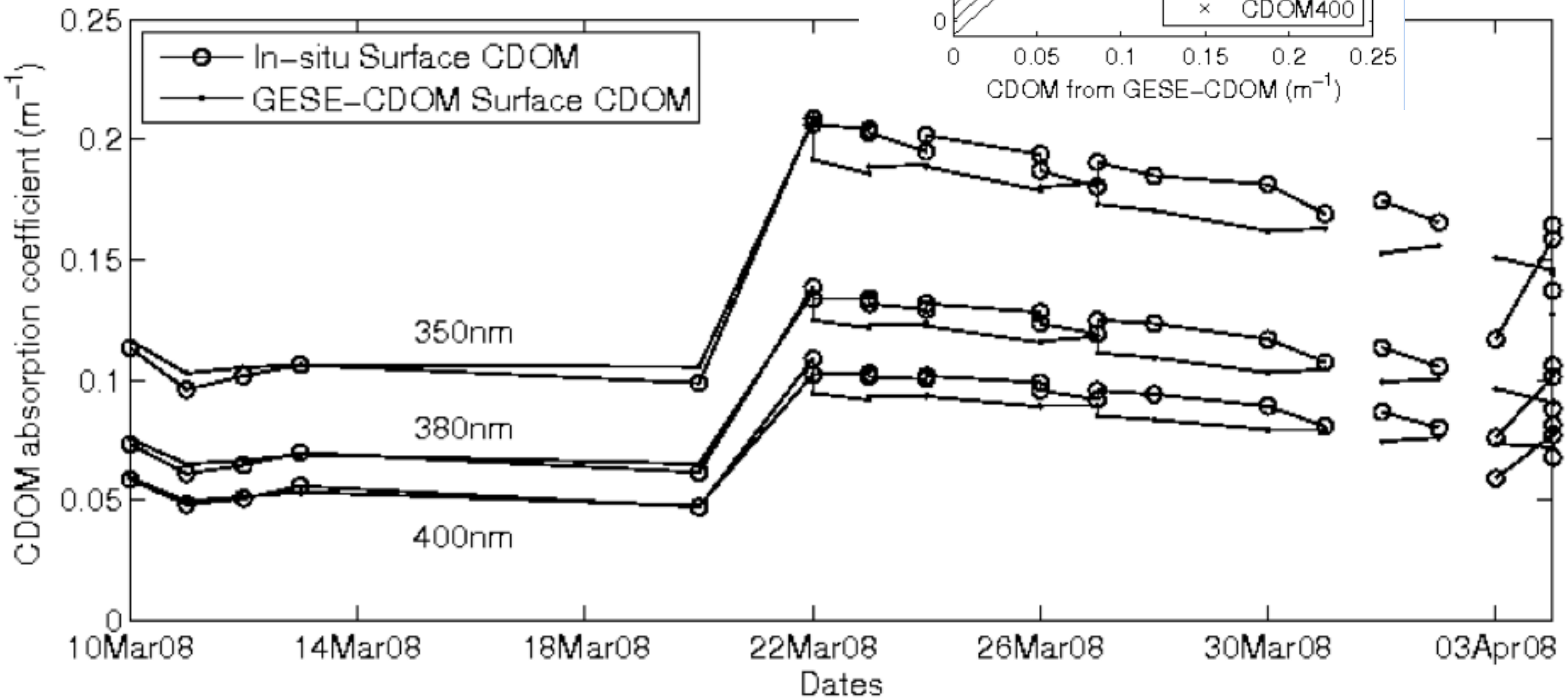


Comparison of the time averaged MODIS-AQUA derived SCDOM field at 350 nm (upper panel), 380 nm (middle panel) and, 400 nm (lower panel) with the corresponding GESE-CDOM SCDOM fields for the SO GasEx domain. The time average is over 21, 22, 24, and 27 March 2008 (the dates of the satellite data). The star and diamonds show the SO GasEx cruise station on 20th March and 22nd March, respectively.

Why the mismatches?
~1. We are measuring remotely at 440 nm and extrapolating to shorter wavelengths using the *S* parameter.
~2. Can the model resolve better the first optical depth?
~3. This is a poor match up.

Comparison between field data (all CTD samples and modeled CDOM)





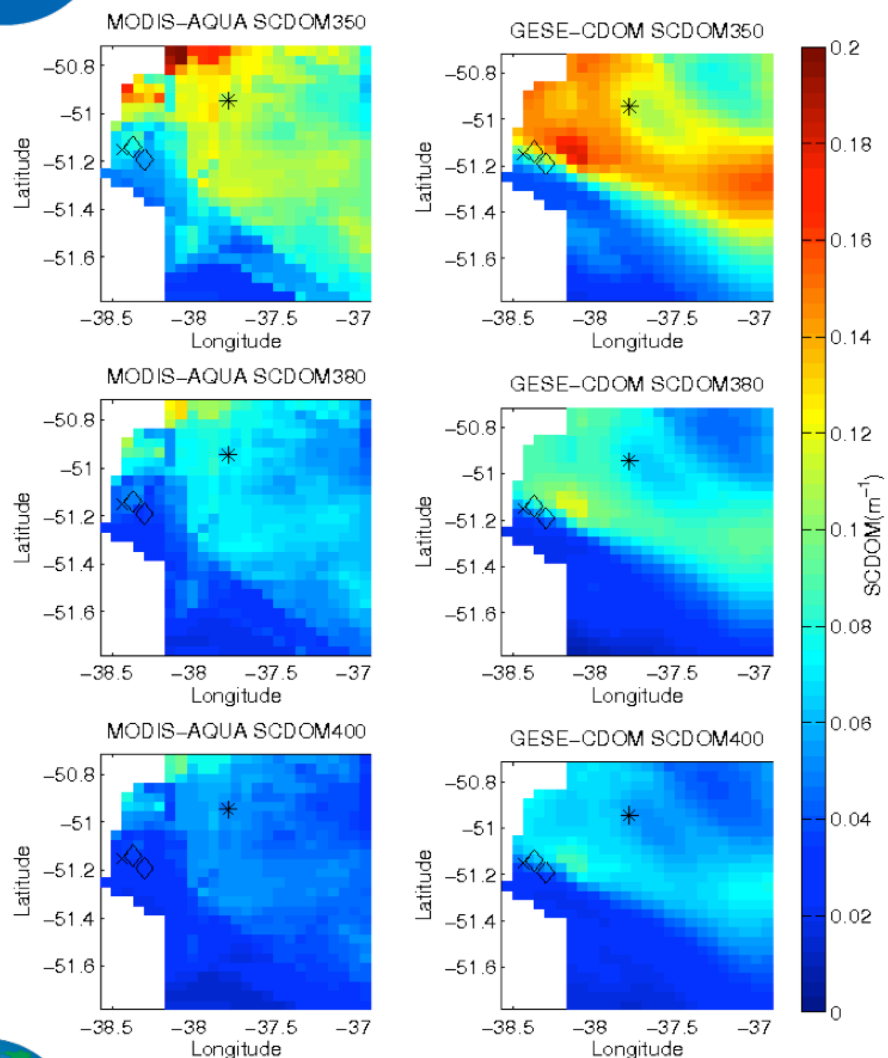
Comparison of the time series of SO GasEx *in-situ* surface CDOM (circles) at 350nm, 380nm, and 400nm with the corresponding GESE-CDOM surface CDOM values (dots). The samples are from surface CTD stations.

I know that this is a horrible slide....

Iteration Number	Normalized Cost function											
	Total	NADT	SST	CTDT	CTDS	SF_6	CDOM 350	CDOM 380	CDOM 400	SCDOM 350	SCDOM 380	SCDOM 400
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	0.33	0.81	0.75	0.27	0.35	0.24	0.09	0.09	0.09	0.55	0.63	0.52
50	0.28	0.81	0.73	0.18	0.29	0.19	0.07	0.06	0.06	0.52	0.60	0.49
75	0.25	0.70	0.72	0.15	0.24	0.16	0.07	0.06	0.06	0.49	0.57	0.47
100	0.24	0.68	0.70	0.14	0.22	0.15	0.06	0.06	0.06	0.48	0.55	0.45
125	0.23	0.67	0.69	0.13	0.20	0.15	0.06	0.06	0.06	0.48	0.54	0.45

Experiment	Total	CDOM350	CDOM380	CDOM400	SCDOM350	SCDOM380	SCDOM400
GESE-CDOM-EN0	1.72	12.60	12.30	8.92	0.89	0.94	0.84
GESE-CDOM-E0	1.14	1.70	3.7	1.10	1.20	1.50	1.02
GESE-CDOM-AD0	5.34	30.20	36.34	28.10	1.30	1.35	1.18
GESE-CDOM-ADDI0	5.58	32.69	39.13	30.22	1.29	1.36	1.16

......sorry......



Conclusions:

1- CDOM distribution in the Southern Ocean in time scales of < weeks is controlled by physical processes. Biological processes are negligible.

2- Data assimilation of remote sensing and field data can produce IOP fields – at least CDOM. Modeled products can compensate for lack of imagery in cloudy environments.

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